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EXPLOITATION OF PRAWN RESOURCES BY TRAWLERS OFF KAKINADA WITH A NOTE ON THE STOCK ASSESSMENT OF COMMERCIALLY IMPORTANT SPECIES

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ABSTRACT

Annual prawn landings by trawlers operating from Kakinada increased gradually from 132 t in 1967 to 6,191 t in 1977 and declined abruptly to 2,026 t in 1978. Effort in trawling hours also indicated more or less a similar trend. The annual CPH indicated four phases in the abundance of prawns over the 12-year period. The annual percentage composition of prawns in the trawler catches varied from 16.7 in 1968 to 30.2 in 1972 with the average at 25 %. Although 38 species of penaeids and a number of non-penaeids were represented in the catches, only *Metapenaeus dobsoni* (28.3%), *M.monoceros* (11.9%), *M. brevicornis* (6.6 %), *M. affinis* (5.9 %), *Penaeus indicus* (4.8 %) and *P. monodon* (4.4 %) formed the mainstay of the fishery. However, during 1977 non-penaeids represented by *Acetes erythraeus, Nematopalaemon tenuipes* and *Hippolysmata ensirostris* formed about 55 % of the prawn catches relegating the penaeids to a secondary status. Length-frequency distribution of penaeid species indicated that there was a decline in the proportion of larger size groups in the latter years. MSY and FMSY have been calculated for different species of penaeids to assess the present status of the stocks of these species. For the penaeids as a group the MSY has been estimated at 2,589 t. The study indicates that almost all the penaeid species are being harvested at the optimum level and any further increase in effort may lead to overfishing of the stocks.

INTRODUCTION

The traditional fishery for prawns off Kakinada is being carried out by small indigenous boats fishing within 3-4 km of the shore. Since 1962 there has been a gradual increase in trawling operations along this coast, and by 1964 a number of commercial boats entered the fishery. At present there are about 300 mechanised boats operating trawl nets from Kakinada. Earliest report on the prospects of trawl fishery in the inshore waters of Kakinada is by Poliakov (1962). Later Satyanarayana and Narayanappa (1972) reviewed the results of experimental trawling for the period 1964-'70. Muthu *et al.* (1975) and Narasimham *et al.* (1979) discussed the catch trends of commercial trawlers for the periods 1967-'70 andl970-'74 respectively. Rao*etal.* (1980) discussed the effects of cod end mesh size reduction on the prawn catches.

This paper presents an analysis of the data relating to the prawn fishery of trawlers operating off Kakinada during the twelve-year period, from 1967 to 1978, with reference to seasonal trends in catch, effort, species composition and length composition of tne commercially important species. Stock assessment of the commercially important penaeid species is also attempted.

FISHING OPERATIONS

Muthu et al. (1975) described the craft and gear of the commercial trawling fleet operating off Kakinada. The pattern of

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fishing operations changed gradually from 1967 to 1978 as a result of the ever-expanding fleet. In the early years boats conducted daily fishing trips, leaving the harbour in the early hours of the day and returning in the afternoon, the time spent in actual fishing by each boat being three to five hours. This convention of day trawling for prawns changed since January, 1974, when some fishermen venturing for night trawling brought good catches of *Metapenaeus monoceros*. Since then it has become customary for the fleet to operate at night in fair weather periods. Similarly boats started trawling continuously for 15 to 20 hours when there were good catches. Some of the boats even conducted week-long voyages when they ventured to look for the new grounds along the coast. When trawling started in 1960's commercial fishing operations were conducted offKakinada between latitude 16°50' and 17° 10' N and longitude 82° 20'and 30' E in depths of 5-40 m (Fig. 1). With the introduction of new boats into the fishery, it has become necessary for the fbet to disperse along the coast and further offshore gradually encompassing new grounds away from the home port.

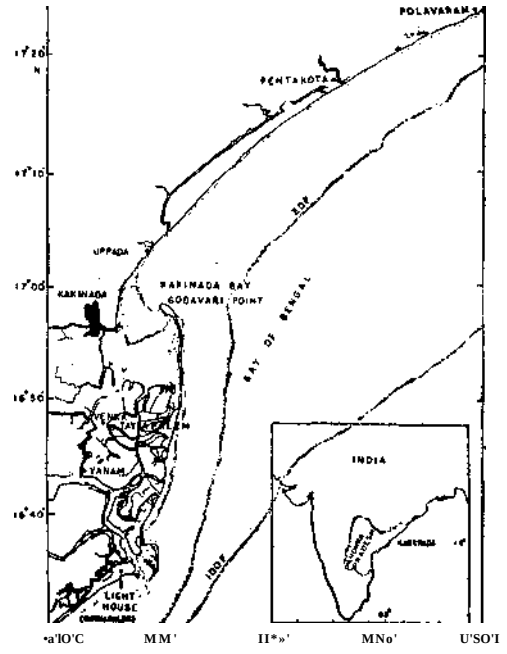

Fig. 1. Map of the Kakinada area.

MATERIAL AND METHODS

As the vast majority of the boats do not maintain any log, it was necessary to follow the procedure generally adopted for indigenous gear catches. Data were collected weekly at the harbour on total catch, effort in units, effort in trawling hours and prawn catch by enquiry, and by eye estimation from 20-30% of the boats landed on the observation days. From these data obtained on the observation days, monthly estimates were computed depending on the number of fishing days in that month. Random samples of prawn catches were collected on observation days for species composition and other biological studies. In the laboratory the samples were segregated into component species and sexes, and the weight and length of individuals recorded. Total length referred to in this report is the distance from the tip of rostrum to the tip of telson. For the analysis of length frequency distribution, 5 mm size grouping was adopted except for *P. monodon*, where 10 mm size grouping was considered.

Stock assessment was made by the surplus yield model proposed by Schaefer (1954) and later revised by Ricker (1975). Garcia and Lereste (1981) discussed the merits and demerits of the method in adopting it for stock assessment of penaeid species. However, if reliable data on catch and effort are available for a number of years, it gives reasonable estimates of maximum sustainable yield (MSY) and the related effort (FMSY). Ramamurthy *et al.* (1975, 1978) and Silas *et al.* (1984) adopted this method to assess the prawn stocks of different areas of the Indian coasts and arrived at reasonably good estimates.

Stock assessment by this method involves only two parameters, namely catch and effort. When effort is plotted against catch/effort the resultant straight line and the regression

constants describing the line gives MSY and the related effort (FMSY) by the equations :

$$MSY = j£ \; ; \; Effort\ (FMSY) = \frac{a}{2b}$$

In the present analysis catch per hour of trawling is considered as the proper catch per unit of effort.

TRENDS IN PRAWN LANDINGS

The estimated monthly landings of prawns during the years 1967-78 are presented in Table 1. During the 12-year period the monthly prawn landings varied from 0.9 t (January, 1967) to 1,297.8 t (June, 1977). Pooled averages for the 12-year period of 1967-78 of catch, effort and CPH are presented in Table 2 to trace the seasonal trends of these parameters. Effort in boat units and fishing hours has exhibited a primary peak in March-May and a secondary peak in August-September. Corresponding peaks for total catch and CPH were absent during these periods. But prawn landings and CPH reached peaks in February-March, June-August and November. It is evident that lower effort in June-July and October-December was due to other factors rather than scarcity of prawns in the grounds. Intermittent unfavourable weather conditions prevalent in these periods, limit the fishing activities along this coast.

Annual data on catch, effort and CPH are presented in Table 3. Catch and effort have more or less gradually increased from 1967 to 1977. Prawn landings which were a meagre 132 t in 1967 gradually increased to 6,191 t by 1977 and sharply declined to 2,026 t in 1978. Similar trend was observed for effort also. The trend in the CPH exhibits an entirely different picture. The annual CPH indicates four phases in the abundance of prawns during the 12-year period of investigation. In the first phase, (1967-'69) CPH was more or less steady and moderate whereas in the second phase (1970-72) the CPH was on the increase. This increase probably indicates the efficiency in the operation of the trawling gear than any real increase in the abundance of prawns in the grounds. In the first phase the boat net combination was in a state of development. The third phase (1973-76) was marked by a sharp fall in the catch rates in 1973 followed by a gradual rise in the CPH by 1976 due to a reduction in the cod end mesh size of trawl nets resulting in the retention of smaller prawns in the net. This trend continued in 1977 and 1978. Inspite

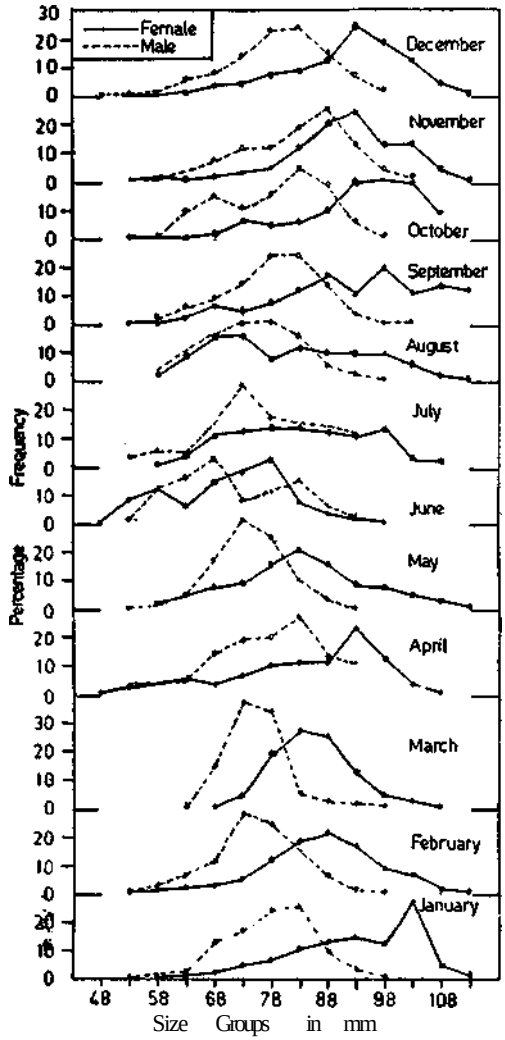

Fig. 2. Monthly length - frequency distribution of *M.dobsoni* (Pooled for the years 1969-78).

TABLE 1. *Monthly prawn landings (in tonnes) by trawlers at Kakinada during the years* 1967-'78

Years	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1967	0.9	7.5	3.7	6.7	6.8	38.4	34.5	13.1	8.8	4.7	6.3	0.9	132.3
1968	9.3	11.1	1.6	30.9	70.4	37.8	59.7	41.7	31.1	7.0	19.4	20.5	340.5
1969	13.0	2.9	7.8	38.3	42.8	21.2	15.0	18.8	43.9	25.2	7.8	31.7	268.4
1970	40.3	25.9	16.3	20.9	77.9	29.8	23.8	28.4	61.3	18.7	17.3	42.0	402.6
1971	25.8	10.1	32.2	41.5	94.4	33.7	21.9	87.2	88.7	42.5	68.2	56.6	602.8
1972	153.9	142.2	18.3	443	41.3	88.3	59.3	99.3	63.3	65.1	56 8	33.7	865.8
1973	58.8	16.7	100.1	79.8	110.1	58.5	51.1	118.0	48.6	60.1	74.5	45.5	821.8
1974	104.7	194.0	280.1	121.2	111.8	74.4	183.1	65.9	66.6	89.9	80.6	59.7	1,432.0
1975	57.0	61.4	108.6	181.3	121.8	135.5	162.1	377.1	125.5	97.9	57.1	139.8	1,625.1
1976	114.7	115.1	681.9	233.5	332.6	182.7	79.3	78.4	370 0	127.7	55.3	57.3	2,428.5
1977	92.7	869.9	302.6	523.9	210.4	1,297.8	1,296.4	222.6	109.4	352.3	655.5	257.7	6,191.2
1978	200.9	201.3	281.8	82.1	67.2	86.0	66.5	483.1	211.4	95.4	209.0	36.0	2,025.7

TABLE 2. *Prawn landings and species composition at Kakinada by trawlers (Pooled averages for the years 1961-1%)*

Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
No. of trawler units	1,788	1,980	2,275	2,360	2,345	1,789	1,525	2,077	1,932	1,383	1,343	1,531	22,327
Trawling time in hrs	13,149	14,554	15,323	15,277	15,040	11,445	9,765	13,541	12,547	8,776	8,644	10,687	1,48,750
Prawn catch in t	73.2	138.2	152.9	117.0	107.3	173.7	171.0	136.6	102.4	82.2	109.0	65.1	1,428.1
% of prawn in total catch	17.3	15.5	18.0	22.9	18.1	54.2	45.6	26.8	24.2	31.9	38.9	21.7	25.1
CPH for prawns	5.5	9.5	10.0	7.7	7.1	17.0	17.5	10.1	8.2	9.4	12.6	6.1	9.7
Species composition by weight in tonnes:													
M. dobsoni	25.1	80.7	97.8	21.6	34.0	17.5	5.6	24.0	29.5	19.1	17.3	32.1	404.4
%	34.3	58.4	64.0	18.5	31.7	10.1	3.3	17.6	28.8	23.2	15.9	49.3	28.3
M. monoceros	13.2	28.0	25.0	34.6	16.8	10.7	12.8	9.1	6.9	2.8	7.3	3.1	170.1
/o	18.0	20.3	16.4	29.6	15.7	6.2	7.5	6.7	6.7	3.4	6.7	4.8	11.9
M. affinis	3.2	1.7	1.7	6.2	7.7	11.9	10.2	14.9	9.5	5.5	6.4	4.7	83.7
/o	4.4	1.2	1.1	5.3	7.2	6.9	6.0	10.9	9.3	6.7	5.9	7.2	5.9
M. brevicornis	3.1	1.6	4.4	7.2	4.0	4.6	7.9	9.4	13.2	11.7	15.1	12.5	94.5
/o	4.2	1.2	2.9	6 2	3.7	2.7	4.6	6.9	12.9	14.2	13.9	19.2	6.6
P. monodon	9.0	9.2	7.6	8.8	5.5	3.1	4.3	5.6	2.9	1.7	2.6	2.0	62.5
%	12.3	6.7	5.0	7.5	5.1	1.8	2.5	4.1	2.8	2.1	2.4	3.1	4.4
P. indicus	6.3	5.4	5.4	9.3	13.9	6.1	5.5	3.8	5.6	2.5	1.9	2.5	67.9
%	8.6	3.9	3.5	8.0	13.0	3.5	3.2	2.8	5.5	3.0	1.7	3.8	4.8
P. merguiensis	1.4	1.7	1.0	0.6	0.8	0.5	0.5	0.5	0.4	0.4	0.5	0.5	8.7
' %	1.9	1.2	0.7	0.5	0.7	0.3	0.3	0.4	0.4	0.5	0.5	0.8	0.6
P. stylifera	0.4	0.2	0.7	2.5	4.5	4.3	4.6	6.1	4.2	2.0	2.1	0.7	32.1
/o	0.6	0.1	0.5	2.1	4.2	2.5	2.7	4.5	4.1	2.4	1.9	1.1	2.2
P. hardwickii	0.4	0.2	0.1	1.6	3.3	2.8	2.2	2.3	2.0	1.0	1.2	0.3	17.3
/o	0.6	0.1	0.1	1.4	3.1	1.6	1.3	1.7	2.0	1.2	1.1	0.5	1.2
S. crassicornis	1.5	2.0	0.9	1.6	4.7	3.0	8.2	5.2	3.1	1.4	0.9	0.7	33.1
%	2.1	1.5	0.6	1.4	4.4	1.7	4.8	3.8	3.0	1.7	0.8	1.1	2.3
Other penaeids	8.5	6.3	6.6	12.4	7.4	4.1	2.9	5.2	2.3	1.8	1.6	3.9	63.5
%	11.6	4.6	4.3	10.6	6.9	2.4	1.7	3.8	2.3	2.2	1.5	6.0	4.4
Non-penaeids	1.1	1.2	1.7	10.6	4.7	105.1	106.3	50.5	22.8	32.3	52.1	2.1	390.3
% .	1.5	0.9	1.1	9.1	4.4	60.5	62.2	37.0	22.3	39.3	47.48	3.2	27.3

TABLE 3. *Annual landings in tonnes (CPH in kg) of different species of penaeids at Kakinada during the years* 1967-'78

Years	Effort in hrs	*P. dobsoni*	*P. monoceros*	*P. affinis*	*M. brevicornis*	*M. monodon*	*M. indicus*	*M. merguiensis*	*M. stylifera*	*M. hardwicki*	*M. crasicornis*	Other penaeids	Total penaeids.
1967	20,183	3.9 (0.2)	20.3 (1.0)	37.0 (1.8)	11.8 (0.6)	16.6 (0.8)	15.5 (0.8)	3.8 (0.2)	2.0 (0.1)	2.0 (0.1)	2.8 (0.1)	3.9 (0.2)	119.6 (5.9)
1968	42,454	41.8 (1.0)	82.8 (2.0)	69.0 (1-6)	35.1 (0.8)	22.1 (0.5)	13.3 (0.3)	0.3 (0.1)	14.9 (0-4)	5.1 (0.1)	21.1 (0-5)	11.9 (0.3)	317.4 (7.5)
1969	34,155	66.3 (1.9)	46.1 (1.4)	49.8 (1.5)	17.3 (0.5)	19.5 (0.6)	14.5 (0-4)	2.1 (0.1)	8.5 (0-3)	5.1 (0.2)	7.0 (0.2)	11.5 (0.3)	247.7 (7.2)
1970	37,701	139.4 (3.7)	60.8 (1.6)	42.0 (1.1)	27.6 (0.7)	38.9 (1.0)	25.1 (0.7)	0.5 (0.1)	9.0 (0.2)	9.2 (0.2)	8.4 .0.2)	8.0 (0.2)	368.9 (9.8)
1971	55,854	195.3 (3.5)	72.8 (1.3)	56.0 (1.0)	85.9 (1.5)	24.8 (0.4)	27.0 (0.5)	1.8 (0.1)	35.2 (0.6)	16.8 (0.3)	26.5 (0.5)	17.8 (0.3)	559.9 (10.0)
1972	67,628	319.2 (4.7)	117.9 (1.7)	77.8 (1.2)	106.8 (1.6)	60.3 (0.9)	90.7 (1.3)	5.4 (0.1)	13.8 (0.2)	7.4 (0.1)	12.2 (0.2)	26.9 (0.4)	838.4 (12.4)
1973	1,34,119	323.2 (2.4)	138.4 (1.0)	62.1 (0.5)	98.3 (0.7)	41.3 (0.3)	42.2 (0.3)	4.2 (0.1)	19.5 (0.2)	7.4 (0.1)	29.0 (0.2)	25.4 (0.2)	791.0 (5.9)
1974	1,76,929	324.7 (18)	485.6 (2.7)	83.4 (0-5)	124.4 (0.7)	92.1 (0.5)	88.3 (0.5)	8.6 (0.1)	51.7 (0-3)	23.2 (0.1)	35.7 (0-2)	59.2 (0-3)	1,376.9 (7.8)
1975	1,87,065	317.4 (1.7)	222.2 (1.2)	245.0 (1-3)	105.2 (0.6)	150.6 (0.8)	94.3 (0-5)	12.1 (0.1)	69.4 (0.4)	30.0 (0.2)	38.0 (0.2)	171.3 (0.9)	1,455.5 (7.8)
1976	2,37,333	1,257.0 (5.3)	168.3 (0.7)	100.0 (0.4)	168.8 (0.7)	101.1 (0.4)	107.5 (0.5)	18.1 (0.1)	78.4 (0-3)	51.6 (0.2)	65.5 (0.3)	192.3 (0.8)	2,308.6 (9.7)
1977	4,14,697	1,482.3 (3.6)	432.2 (1.0)	82.0 (0.2)	185.3 (0.5)	63.6 (0.2)	237.8 (0.6)	26.9 (0.1)	28.8 (0.1)	12.3 (0.1)	92.4 (0.2)	125.9 (0.3)	2,769.7 (6.7)
1978	3,76,881	382.0 (1.0)	194.0 (0-5)	100.0 (0.3)	164.0 (0.4)	119.0 (0.3)	59.0 (0.2)	20.0 (0.1)	47.0 (0.1)	28.0 (0.1)	59.0 (0.2)	154.0 (0.4)	1,326.0 (3.5)

of a drastic reduction in the cod end mesh size, the CPH showed an all-time low value in 1978 indicating a fourth phase. Although a micro-analysis of the data indicates that there are four phases in the CPH of prawns (as a group) during the period under report, the individual annual CPH did not deviate far from the average annual CPH of 9.7 kg.

Pooled monthly averages for percentage composition of prawns in the total catch represented peaks in June-July and October-November as a result of landing of non-penaeids in these periods. The annual percentage composition of prawns in the trawl catches varied from 16.7 in 1968 to 30.2 in 1972. During the twelve year period (Rao *et al.,* 1980), pooled data for all the years show that prawns formed about 25.1 % of trawler catches. This confirms the observations of Shree Krishna and Narayanappa (1970) and Muthu *et al.* (1975).

SPECIES COMPOSITION

Muthu (1968) recorded 37 species of penaeids along the Kakinada coast. All these species were observed in the catches during the present investigation also. Although a number of penaeids and non-penaeids were represented in the catches, only *Metapenaeus dobsoni, M. affinis, M. monoceros, M. brevicornis, Penaeus indicus, P. monodon, P. merguiensis, Parapenaeopsis stylifera, P.hardwickii, Solenocera crassicornis, Nematopalaemon tenuipes, Exhippolysmata ensirostris, Acetes erythraeus* and *A. indicus* were landed in commercial pioportions. Penaeids occurring in negligible quantities are grouped as 'Other penaeids.' The relative proportion of such species in the catches is mentioned in the section dealing with individual species. Pooled monthly averages of different species are presented in Table 2 and annual landings and CPH are presented in Table 3.

M. dobsoni: Although *M. dobsoni* was landed throughout the year the catches were better during December-March period. During this period it formed about 50% of the prawn catches. Poorest landings were observed in June-July period (Table 2). The annual landings gradually increased from 3.9 t in 1967 to 1,482.5 t in 1977 and declined sharply in 1978 whereas the CPH depicted a different trend. CPH gradually increased from 0.2 kg in 1967 to 4.7 kg in 1972, then declined gradually to 1.7 kg in 1975 and reached a peak of 5.3 kg in 1976 followed by a sharp fall to 1.0 kg in 1978.

Pooled monthly length frequency distribution for males and females for the years 1969-'78 is presented in Fig. 3. Males of 43-103 mm and females of 43-113 mm were represented in the catches with a multimodal distribution in most of the months. During

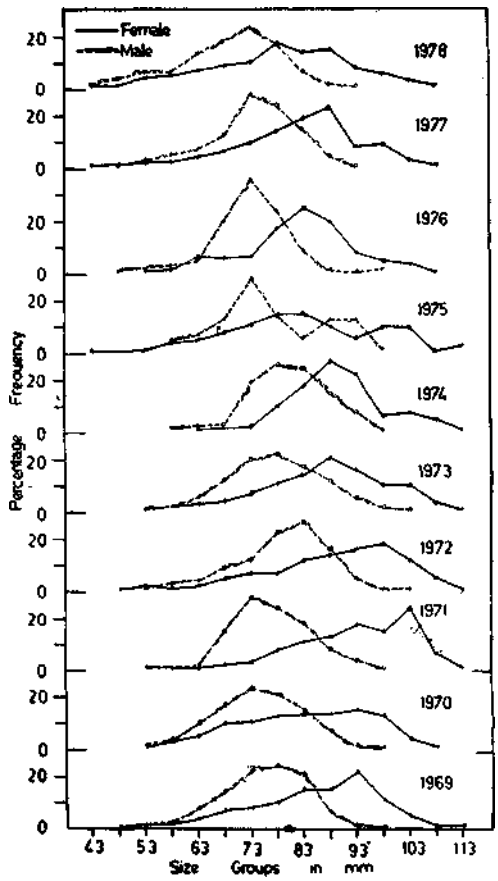

Fig. 3. Annual length - frequency distribution of *M. dobsoni* for the years 1969-'78.

the peak season of the fishery in January-March, bigger size groups formed the bulk of the catches. The contribution of smaller size groups to the fishery increased gradually from April and reached a peak by December. It clearly shows that the species spawns for about nine months in a year and the resultant broods are recruited to the trawler fishery for about nine months.

Annual length-frequency distribution for males and females is given in Fig. 4. The frequency distribution was unimodal for males and females in all the years and the contribution of different size groups to the fishery was similar during the years 1969-74 with a better representation of bigger size groups. During the years 1975-78 there was a gradual decline in the proportion of the bigger size groups in the catches. This may be the result of heavy fishing pressure on the stocks. The surplus yield modal fitted to the data gave a and b values as 2.3777 and 0.0013 respectively. Based on these values, the MSY was calculated as 1,084 t and the effort required to fish this catch as 9,12,142 trawling hours. It is interesting to note here that during the years 1976-77 the catch was more than the maximum sustainable yield as a result of fishing with reduced mesh size cod ends harvesting even the juveniles. However, this trend did not last long and the fishery declined sharply in 1978. Hence it appears reasonable to fish below the MSY for proper maintenance of the fishery.

M. monoceros: The season for *M. monoceros* fishery generally starts in January and reaches a peak by April and declines sharply in June (Table 2) and continues to be in that state during the rest of the year. On an average *M. monoceros* formed about 12 % of the annual prawn landings varying from 7 to 34% in different years. With a modest fishery, yielding 20 t in 1967, the fishery reached a climax in 1974 (485 t) registering a CPH of 2.7 kg. The reduction in the catch duiing 1975.and 1976 inspite of an increase in the effort was an alarming indication of over-fishing of the stocks. Although the fishery appeared to have revived in 1977 with an estimated catch of 432 t, the CPH was only 1.0 kg.

Monthly length - frequency distribution pooled for the years 1970-78 for males and females is given in Fig. 4. Females of 98-168 mm and males of 98-138 mm formed the mainstay of the fishery during January-August with minor deviations in different months. Juveniles dominated the fishery in November-December indicating a peak in the recruitment during these months.

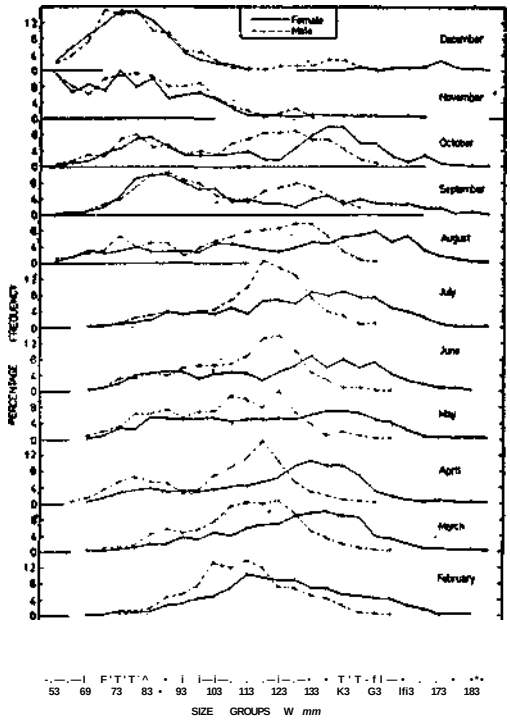

Fig. 4. Monthly length-frequency distribution of *M. monoceros* (Pooled for the years 1970-78).

Annual length-frequency distribution for males and females for the years 1970-78 indicated multimodal distribution in all the years (Fig. 5). The contribution of various size groups showed minor deviations during 1970-74 whereas during 1975-78 the proportion of smaller size groups gradually increased. This may be either due to a reduction in the proportion of bigger size

groups in the fishery or due to a reduction in the mesh size of the cod ends of the trawl nets. The surplus yield model fitted to the data gave a and b values as 1.62 and 0.0018 respectively. Based on these values the MSY and the corresponding effort were calculated at 3611 and 4,46,035 trawling hours. It may be noted here that the catch in 1974 and 1977 far exceeded the MSY; this was followed by a decline in the catch of this species in the succeeding year on both the occasions.

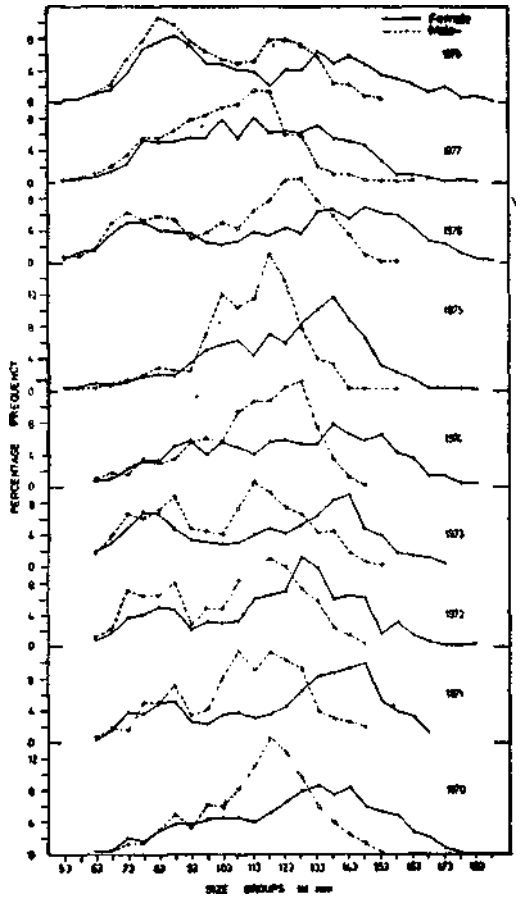

Fig. 5. Annual length-frequency distribution of *M. monoceros* for the years 1970 - '78.

M. affinis: With average annual landings estimated at 84 t, this species formed about 6% of the trawler prawn landings during 1967-'78 period (Table 2). Although it was landed throughout the year the landings were better during June - September period. Annual landings fluctuated from 37 t in 1967 to 255 t in 1975 but the CPH has declined gradually from 1967 (1.83 kg) to 1977 (0.27 kg) with an exception in 1975 (Table 3). Similarly the proportion of *M. affinis* in the prawn landings also declined gradually from 1967 (28 %) to 1977 (1 %).

Pooled monthly length frequency distribution for males and females for the years 1966-73 indicated the presence of females of 53-188 mm and males of 58-158 mm in the catches (Fig. 6). Females of 78-138 mm and males of 78-128 mm contributed to the fishery with deviations in different months. Annual length-frequency distribution (Fig. 7),

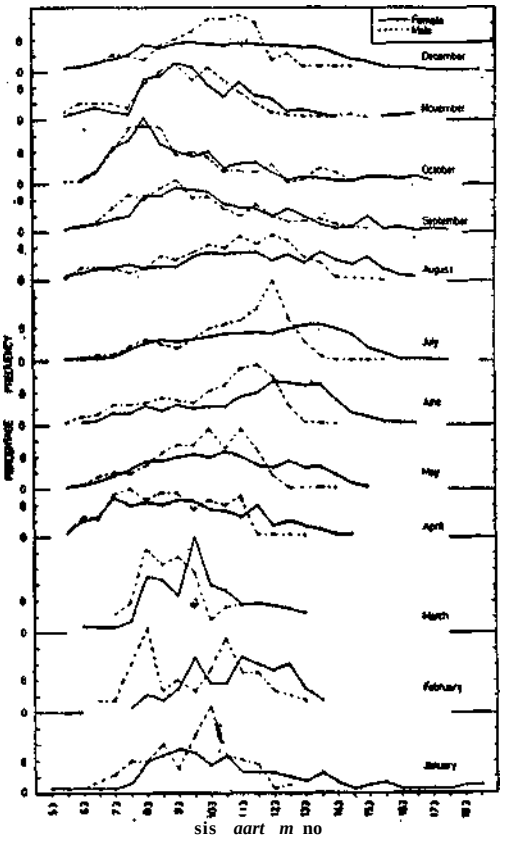

Fig. 6. Monthly length-frequency distribution of *M. affinis* (Pooled for the years 1967-'73).

showed that the contribution of bigger size groups has declined considerably after 1970.

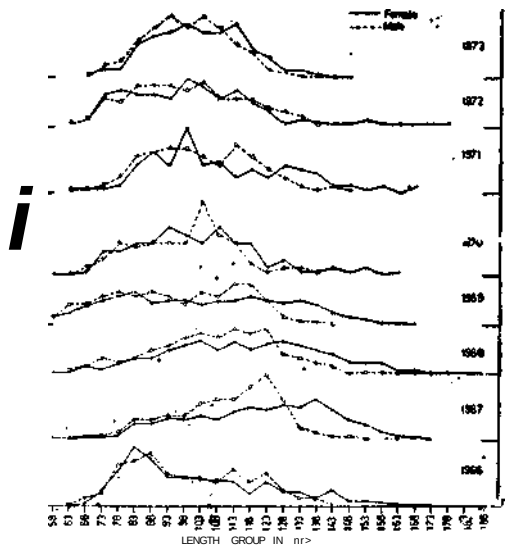

Fig. 7. Annual length-frequency distribution of *M. affinis* for the years 1967-73.

The surplus yield model fitted to the data gave a and b values as 1.4401 and 0.00335 respectively and the MSY was calculated at 154 t with a corresponding effort of 2,14,940 hours. The catch in 1975 far exceeded the MSY and as a result the CPH has declined further in subsequent years. It is evident that the stocks of *M. affinis* are overfished off Kakinada and measures should be taken to limit the catch at MSY so that the fishery does not face overfishing.

M. brevicornis: Although *M. brevicornis* was represented in the catches throughout the year, the fishery was good only during July-December. The fishery was very poor during January-March. Annual landings fluctuating from 12 to 183 t, *M. brevicornis* formed about 6.6% of the trawler prawn landings (Table 3). Annual landings gradually increased from 1967 to 1977, whereas the CPH showed a general decline after 1972. The surplus yield model fitted to the data gave a and b values as 0.97366 and 0.001285 respectively and the MSY was calculated at 1891 with a corresponding effort of 3,78,809 hours.

Monthly length-frequency distribution pooled for the years 1966-'73 for males and females indicated the representation of females by 53-153 mm and males by 53-98 mm (Fig. 8). The length-frequency distribution was uni modal for both the sexes in most of the months. Females of 88-128 mm and males of 68-88 mm formed the bulk of the fishery in most of the months. Annual

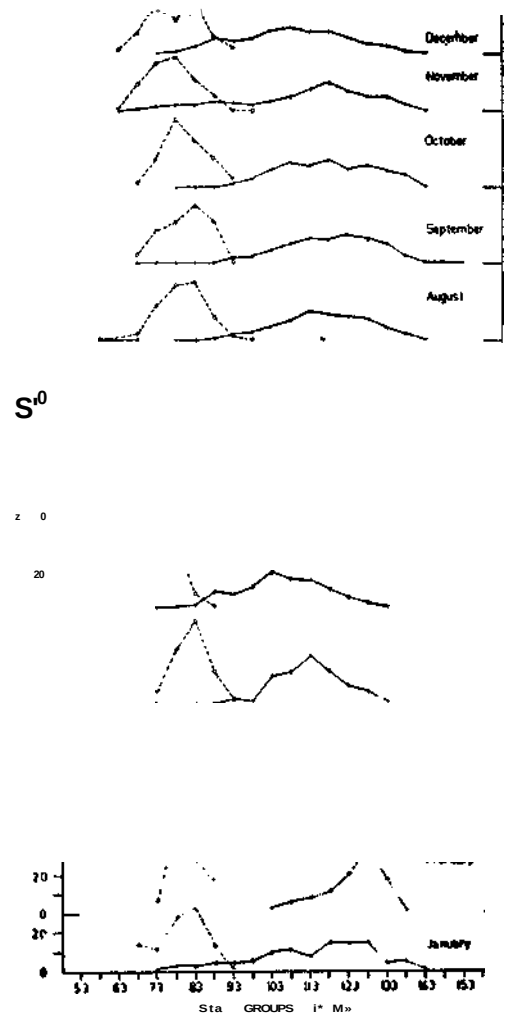

Fig. 8. Monthly length-frequency of *M. brevicornis* (Pooled for the years 1967-'73).

length-frequency distribution during the years 1966-'73 varied little from year to year (Fig. 9).

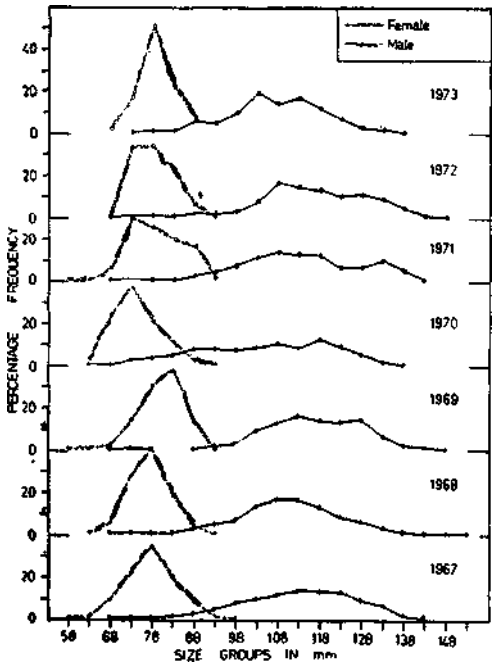

Fig. 9. Annual length-frequency distribution of *M. brevicornis* for the years 1967-'73.

P. monodon: Although *P. monodon* is widely distributed in the Indo-Pacific, it rarely forms a commercial fishery anywhere in the region. The trawler prawn fishery of the Kakinada area is unique in that *P. monodon* form about 4.5% of the prawn landings. The fishery was. generally better during January-May and then declined (Table 2). The fishery was better in alternate years during the years 1967-74 and reached a peak in 1975 (150.6 t) and then declined in 1977 (63.6 t). Annual CPH also indicated a similar trend.

Pooled monthly length-frequency distribution for the years 1970-71 and 1975-78 is given in Fig. 10. The length-frequency distribution was multimodal for both the sexes in most of the months with females of 185-285 mm and males of 165-235 mm forming the mainstay of the fishery. Juveniles formed a good proportion of the fishery throughout April-December indicating a prolonged period of recruitment.

Annual length-frequency distribution for males and females for the years 1970, 1971 and 1975-78 shows that the proportion of juveniles was more in the latter period. This coupled with the decline in CPH in latter years indicate a threat of overfishing if the landings are not limited to MSY. The

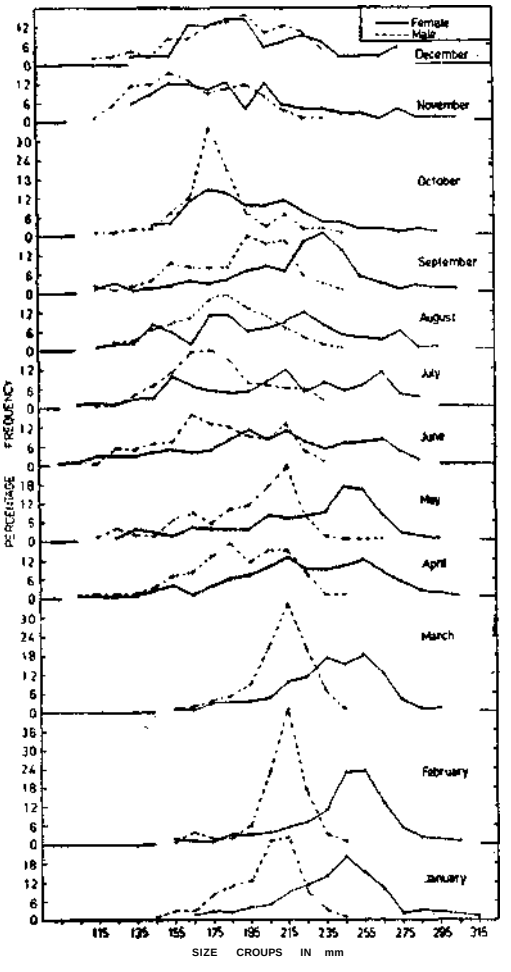

Fig. 10. Monthly length-frequency distribution of *P. monodon* (Pooled for the years 1970, 1971, 1976 & 1977).

surplus yield model fitted to the data gave a and b values as 0.76 and 0.0012945 and the MSY was calculated at 112 t with a corresponding effort of 2,93,550 trawling hours (Table 4). The fishery exceeded MSY in 1975 and as a consequence the CPH during the 1976-78 showed a drastic decline.

P. indicus: Average annual landings estimated at 67.91, *P. indicus* formed about 4.87% of the trawler prawn landings. It was landed in considerable quantities throughout the January-September period reaching a peak in May (Table 2). Annual landings gradually increased from 1968 (13.3 t) to 1977 (238 t) and then dropped sharply in 1978. CPH has also indicated a similar trend.

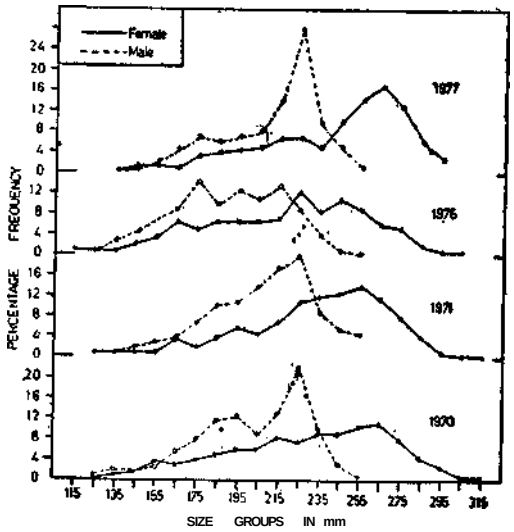

Fig. 11. Annual length-frequency distribution of *P. monodon* for the years 1970, 1971, 1976 and 1977.

Monthly length-frequency distribution pooled for the years 1970, 1971 and 1972 indicated the representation of females of 98-218 mm and males of 98-193 mm in the catches (Fig. 12). Smaller size groups were observed in the catches in all the months indicating continuous recruitment to the trawler fishery. Bigger size groups dominated the fishery in January-April whereas they were poorly represented in May-July. There was a gradual increase of bigger size groups in the fishery from July to October. Annual length-frequency distribution for the years 1970-'72 showed random variations in different years (Fig. 13).

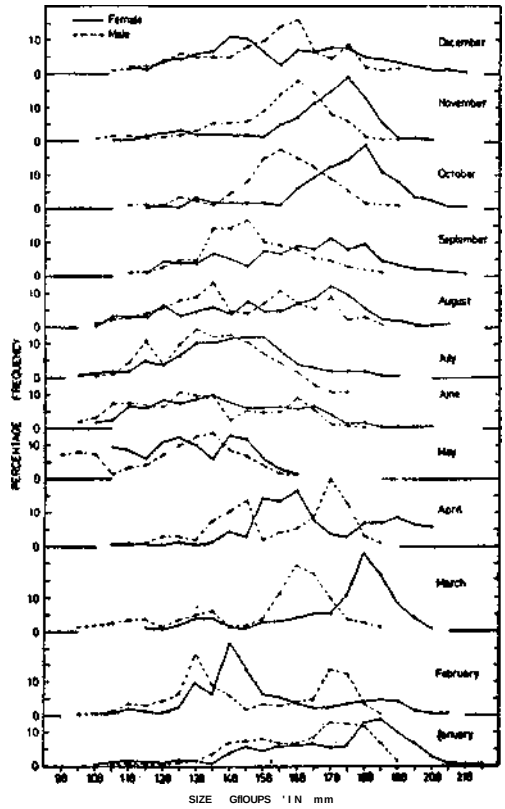

Fig. 12. Monthly length-frequency distribution of *P. indicus* (Pooled for the years 1970-72).

The yield model fitted to the data gave a and b values as 0.6529 and 0.0007524 respectively and the MSY was calculated at 142 t with a corresponding effort of 4,33,878 trawling hours (Table 4). The fishery harvested more than the MSY in 1977 and as a result the fishery failed in 1978.

P. merguiensis: Average annual landings estimated at 8.7 t, this species formed only 0.6% of the prawn landings. The landings were generally better in January-April when compared to the other months (Table 2).

Annual landings more or less gradually increased from 1968 (0.3 t) to 1977 (27 t) and then declined slightly in 1978 (20 t). The surplus yield model fitted to the data gave a and b values as 0.0617 and 0.00000115 respectively and the MSY was calculated at 82 t with a corresponding effort of 26,82,609 trawling hours (Table 4).

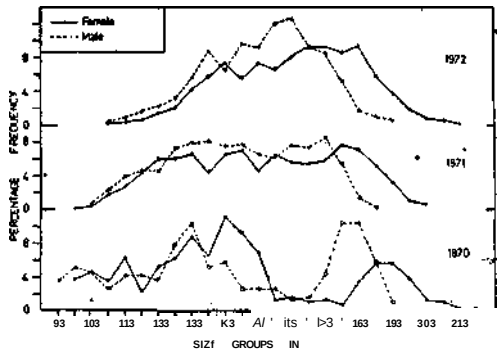

Fig. 13. Annual length - frequency distribution of *P. indicus* for the years 1970-72.

P. stylifera: This species formed about 2.2 % of the prawn landings with the average annual landings of 32.1 t (Table 2). The landings were generally better during May-September than in the other periods. In general it can be said that the annual landings gradually increased from 1967 (2 t) to 1976 (78.4 t) and then declined in 1977 and 1978. Based on the surplus yield model the MSY was calculated at 611 with a corresponding effort of 3,81,548 trawling hours. The fishery harvested more than this in 1975 and 1976 and the after effects were bad as can be seen in the lower landings and CPH (Table 3).

P. hardwickii: With average annual landings estimated at 17.31, *P. hardwickii* formed about 1.2% of the prawn landings. The landings were generally better in May-September when compared to the other months (Table 2). Annual landings gradually increased from 1967 (2 t) and reached a peak in 1976 (51.6 t) and then declined in 1977 and 1978. Based on the surplus yield model the MSY was calculated at 30 t with the corresponding effort of 3,37,594 trawling hours (Table 4). It is seen that the catch exceeded MSY in 1976 and as a result the fishery declined sharply in 1977 with a poor CPH (0.1 kg).

S. crassicornis: S. crassicornis formed about 2.3 % of the prawn landings with the average landings estimated at 33 t. The landings were generally better in May-September when compared with the other months (Table 2). The annual landings gradually increased from 1967 (2.8 t) to 1977 (92.4 t) and declined in 1978. Based on the surplus yield model the MSY was calculated at 851 with the corresponding effort of 5,96.491 trawling hours.

Other Penaeids: A number of penaeids which were landed in considerable quantities only in some seasons and whose landings were comparatively of less economic consequence to the fisheiy are grouped as 'other penaeids.' Some of the species like *Parapenaeus longipes, Metapenaeopsis stridulans* and *Trachypenaeus curvirostris* which were raiely observed in the earliei years were landed in considerable quantities in the later years. The landings of 'other penaeids' were generally better during January-May than in the other months (Table 2). The landings of 'other penaeids' gradually increased from 1967 (3.9 t) to 1976 (192.3 t) and then declined in 1977 and 1978 with poor CPH (Table 3). Based on surplus yield model MSY was calculated at 47 t with the corresponding effort of 2,96,597 trawling hours (Table 4).

Non-penaeids: Non-penaeids mainly represented by *Acetes erythraeus, Namatoplaemon tenuipes* and *Exhippolysmata ensirostris* were landed in good quantities during June-November. Generally the landings were poor in January-March. Annual landings gradually increased from 13 t in 1967 to 3,420 t in 1977 and declined to 730 t in 1978. The unusually heavy landings of 1977 were mainly due to the reduction of mesh size of the cod ends of trawl nets (Rao *et al.,* 1980).

DISCUSSION

It is seen from Table 3 that the penaeid prawn landings gradually increased from 120 t in 1967 to 2770 t in 1977 and declined to

TABLE 4. *MSY calculation for penaeid prawn species off Kakinada*

Species	b	a	MSY in tonnes	Effort in trawling hrs.
M. dobsoni	0.0013	2.3777	1,084	9,12,142
M. monoceros	0.0018	1.62	361	4,46,035
M. affinis	0.00335	1.4401	154	2,14,940
M. brevicornis	0.001285	0.97366	189	3,78,809
P. indicus	0.0007524	0.6529	142	4,33,878
P. monodon	0.0012945	0.76	112	2,93,550
P. merguiensis	0.0000115	0.0617	82	26,82,609
P. stylifera	0.00042	0.3205	61	3,81,548
P. hardwickii	0.000266	0.1796	30	3,37,594
S. crassicomls	0.0002394	0.2856	85	5,96,491
Other penaeids	0.000529	0.3138	47	2,96,597
Total	—		2,347	
Penaeid prawns as a group	0.0078897	9.04	2,589	5,72,899

1,326 t in 1978. However, the CPH indicated a different trend, increasing from 1967 (5.9 kg) to 1972 (12.4 kg) and then declining sharply in 1973 (5.9 kg). Once again there was an upward trend from 1973 to 1976 (9.7 kg) and a decline in 1978 (3.5 kg). Based on the surplus yield model fitted to the data, the MSYof penaeids was calculated at 2,5891 with the corresponding effort at 5,72,898 trawling hours. This appears to be reasonable as the combined total of MSY of different species (2,347 t) closely corresponds to this value. Further it is observed that whenever the landings of any species exceeded its MSY, its fishery in the following years declined considerably. Hence it is believed that the surplus yield model reasonably describes the variations in the prawn fishery of Kakinada.

It is evident from the above analysis that the trawler prawn fishery at Kakinada is of considerable magnitude. Along the east coast only in this region prawns form an important constituent of the trawler catches throughout the year. The fishery is unique in having a number of species contributing to the fishery. It is also interesting to note that *Penaeus monodon*, the biggest of marine prawns and widely distributed in the Indo-Pacific, contributes to about 4.4% to the prawn fishery here.

In the present study no 'shrinkage' (Rounsefell, 1975) in the distribution of different species contributing to the trawler prawn fishery was noticed. Similarly no explosion of prey species was observed in the area. But changes in species composition were evident during the period of observation. *M. affinis* which formed about 27.9% in 1967 gradually lost its importance by 1977. On the other hand, non-penaeids which formed only a negligible portion of the catches earlier, formed about 57.5% from 1977 onwards. Similar fluctuations were observed in respect of the other species also, particularly after 1975. *A. erythraeus* which was never observed in the trawler catches before 1977 was landed in enormous quantities in 1977 and 1978 relegating penaeid pi awns to a secondary status. The explosion of non-penaeid resource is partly because of a reduction in the mesh size of the cod end of trawl nets as pointed out by Rao *et al*. (1980). At the same time the decline

in the percentage composition of *M. affinis* clearly indicates that it was probably exploited beyond its capacity to replenish.

There was a gradual shifting of fishing areas from 1967 to, 1977. Before 1970, most of the boats concentrated their effort around Kakinada(16°50'-17°10' N latitudes) within 40 m depth (Fig. 1). In later years particularly after 1974, the boats started fishing the grounds far away from Kakinada, extending upto Kothapalem(16° 30' N latitude) on the south and Polavaram (17°20'N latitude) on the north and upto 80 m depth. Presently very few boats fish in the grounds near Kakinada. This clearly indicates a shifting of the fishing grounds. Even in the far off grounds the catch rates came down drastically during the 1976-'78 period.

The size composition of different species fluctuated considerably over the years. *M.dobsoni* and *M. monoceros* which together formed about 40% of the catches showed a gradual declining trend in the mean size from 1971 and 1975 respectively. Bigger size groups of these species which were well represented in the landings became scarce in the later years.

The catch per unit of effort which fluctuated over the years indicated an over-all declining trend in the later years, particularly after 1972. The peak in catch rate observed in 1976 and 1977 is very deceptive as this was manifested because of the reduction of cod end mesh sizes in the trawl nets and consequent heavy catches of non-penaeids which are not of much value to the fishing industry. In fact the increase in the total landings during 1976 and 1977 was also due to this reason. In spite of extending the fishery to nearby virgin grounds the declining trend in CPH is still visible. Similar trend was observed by George *et al.* (1968) in the trawler prawn fishery of the Cochin area for the period 1956-'63, by Banerji and Chakraborty (1970) in the prawn fishery of the Kerala coast for the period 1957-'69 and also by Mohamcd and Rao (1973). According to them, however, prawns were not overfished as the total landings of prawns showed an increasing trend.

Narasimham *et al.* (1979) calculated the rates of return on the investment on mechanised boats at 10.5% on 'pablos', 20.9% on 'pomfrets' and 17.0% on 'sorrahs' foi 1974. If the same is calculated at 1978 catch lates, the values scale down to 6.5 % for 'pablos', 13.0% for 'pomfrets' and 10.6% for 'sorrahs', which might be taken as an indication of economic overfishing. The reduction in the mesh size of trawls that was initiated at the close of 1976 as an attempt to increase the catch and thereby compensate for the declining profits did not give the desired results. This sort of drastic changes in the mesh size of the cod end is also an indirect evidence to show that fishing is economically at a low ebb after 1976.

Kesteven (1971) diagnosed five phases in the history of a fishery if no management measures are taken to regulate the fishery. They are 'nascent' fishery, 'developing' fishery, 'stablized' fishery, 'declining' fishery and 'extinguished' fishery. The trawler prawn fishery of Kakinada passed through the first three phases and it is at the threshold of the fourth phase. However, it will not enter into the fifth phase because of the high fecundity of prawns (Neal, 1974). Hence, it is time to think in terms of scientific management and conservation of this fishery.

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